

# **Scintillation Modeling & Simulation**

## **‘Dial-A-Frequency Technology’**

**Presented to**

**ASNE MSEA Technical Interchange**  
**Meeting**

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**Radex, Inc.**



**Asheville, NC**  
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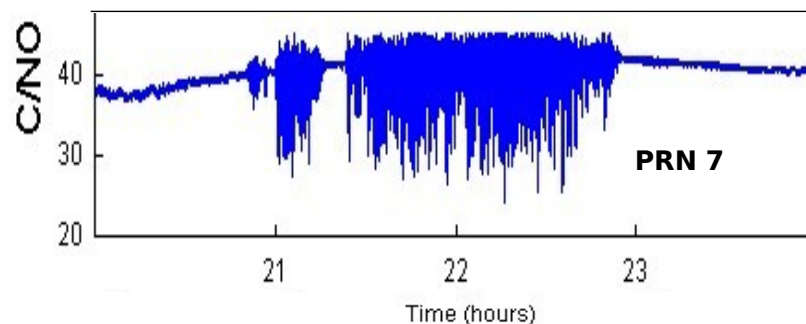
**Keith Groves**  
**AFRL/VSBX**





# Outline

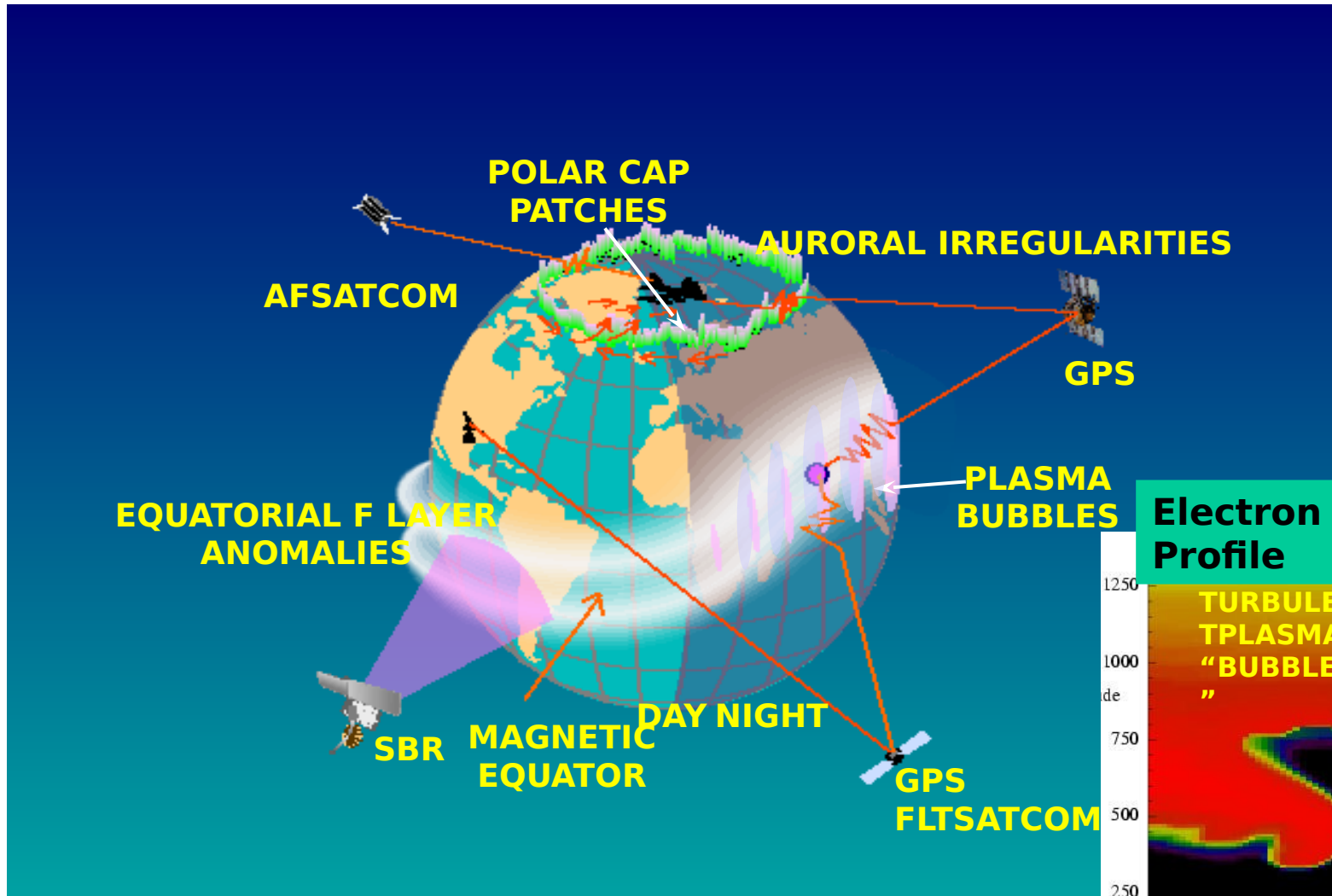
- Ionospheric Scintillation Environment
- Existing fixed frequency band simulation tools
- 'Dial-A-Frequency' Technology (DAFT)
- Summary & Conclusions



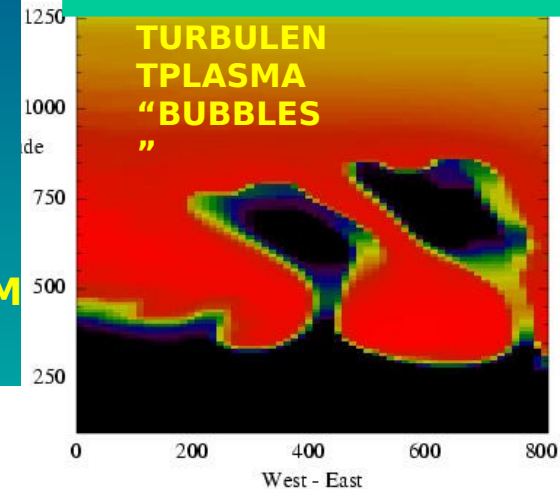
Scintillated GPS Signal  
(Amplitude)



# Disturbed Ionospheric Regions and Systems Affected by Scintillation



## Electron Density Profile





# AFCCC Scintillation Program Status

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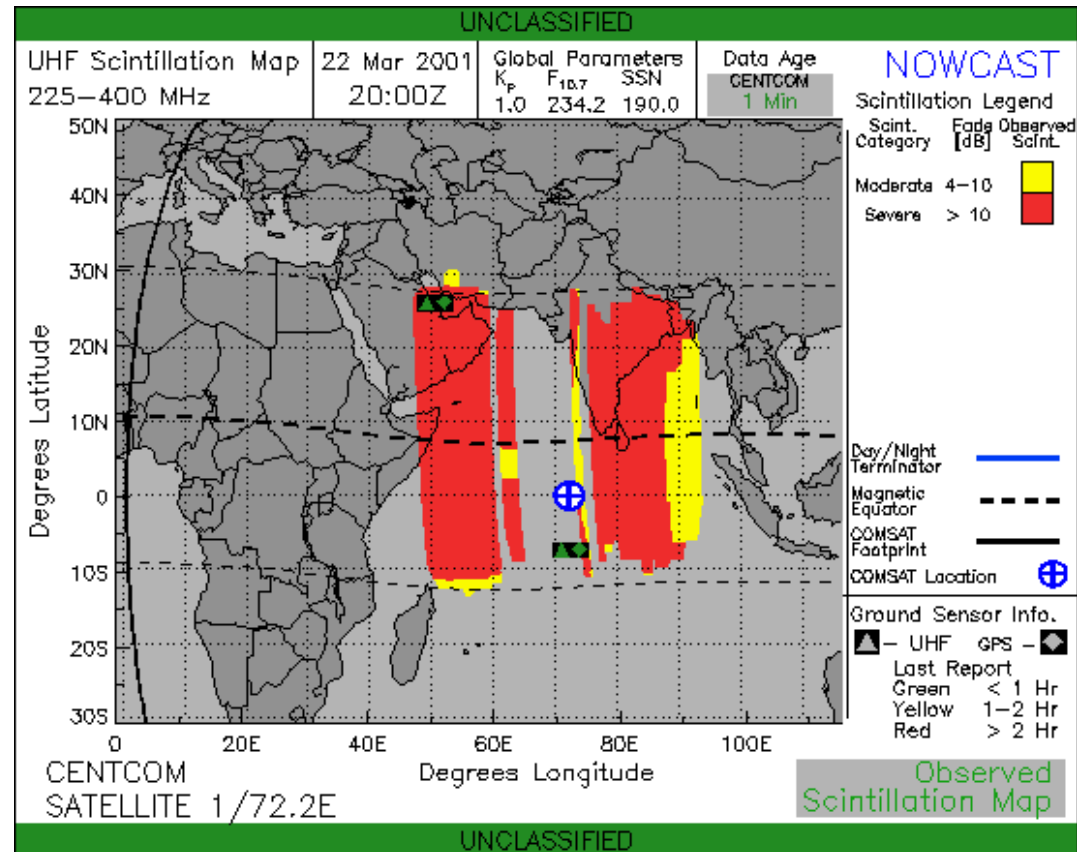
- Original IONSCINT developed to support UHF SATCOM (240-270 MHz) users
  - Realistic structure & variability consistent with climatology
  - Regional impact maps within selected SATCOM footprint
- IONSCINT- G addresses scintillation at GPS L1 (1575 MHz) frequency
  - Product tailored to GPS users (all-sky, platform-based output)
  - Integrated in GPS Interference And Navigation Tool (GIANT)
  - Science module integrated in GEOSpace Sep04
  - S4-threshold based navigation error tool will be incorporated by Dec04
- 'New' IONSCINT featuring 'DAFT' to be delivered Dec04
  - Supports *common environment* for user-selected 200-2000 MHz scintillation impacts (comm, nav, isr impacts)



# IONSCINT SATCOM Output Sample



- Output tailored to specific satellite footprint at specific frequencies
  - Limited UHF SATCOM constellation facilitates large regional maps
- Results do not provide a generalized description of the space environment





# IONSCINT G



## Objective

**Generate variable time-dependent, structured representations of nightly L-band scintillation activity statistically consistent with known climatology**

Integrate with GPS Interference and Navigation Tool (GIANT) Model used for assessing GPS-reliant weapons systems effectiveness

- User Defined Regions & Platforms
- Scintillation Database to Include CY2000-02 for Peak Solar Maximum Conditions

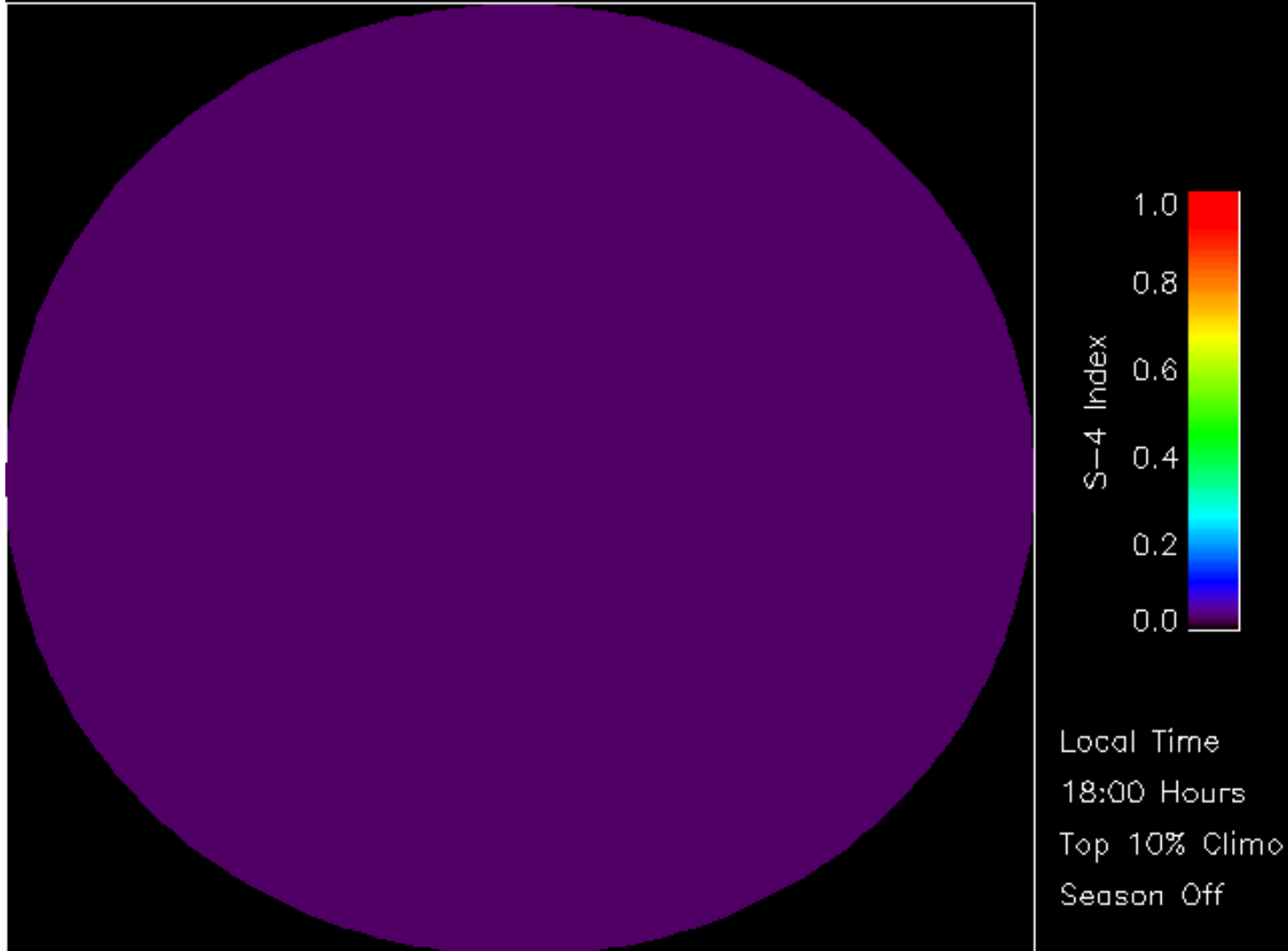


# GPS Scintillation Simulation IONSCINT-G

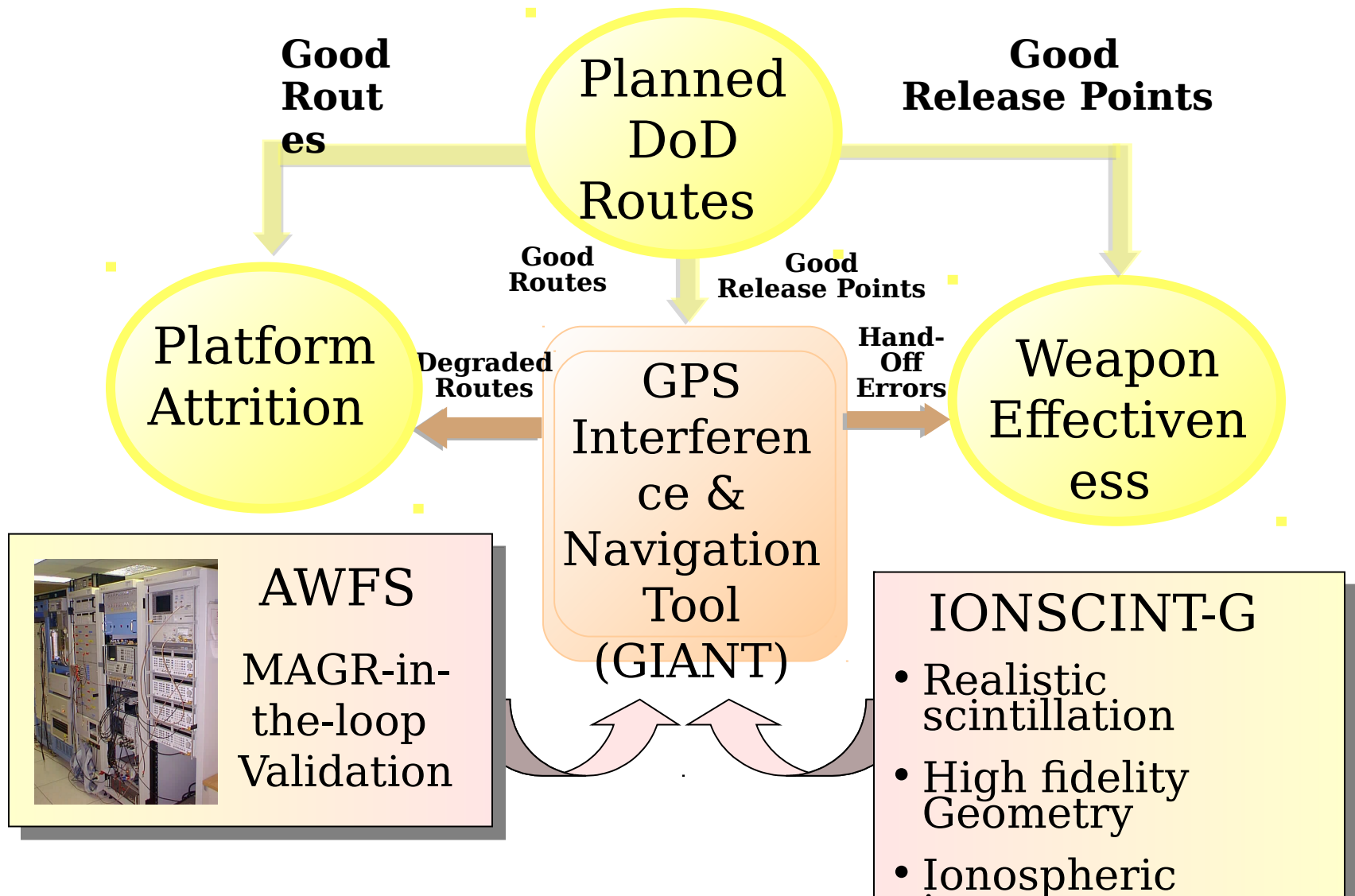


- Simulation of GPS scintillation observed from a platform moving north at 250 m/s

IONSCINT-G on Day 50 at 05:00 UT -40.24 Mlat 195.00 Elon



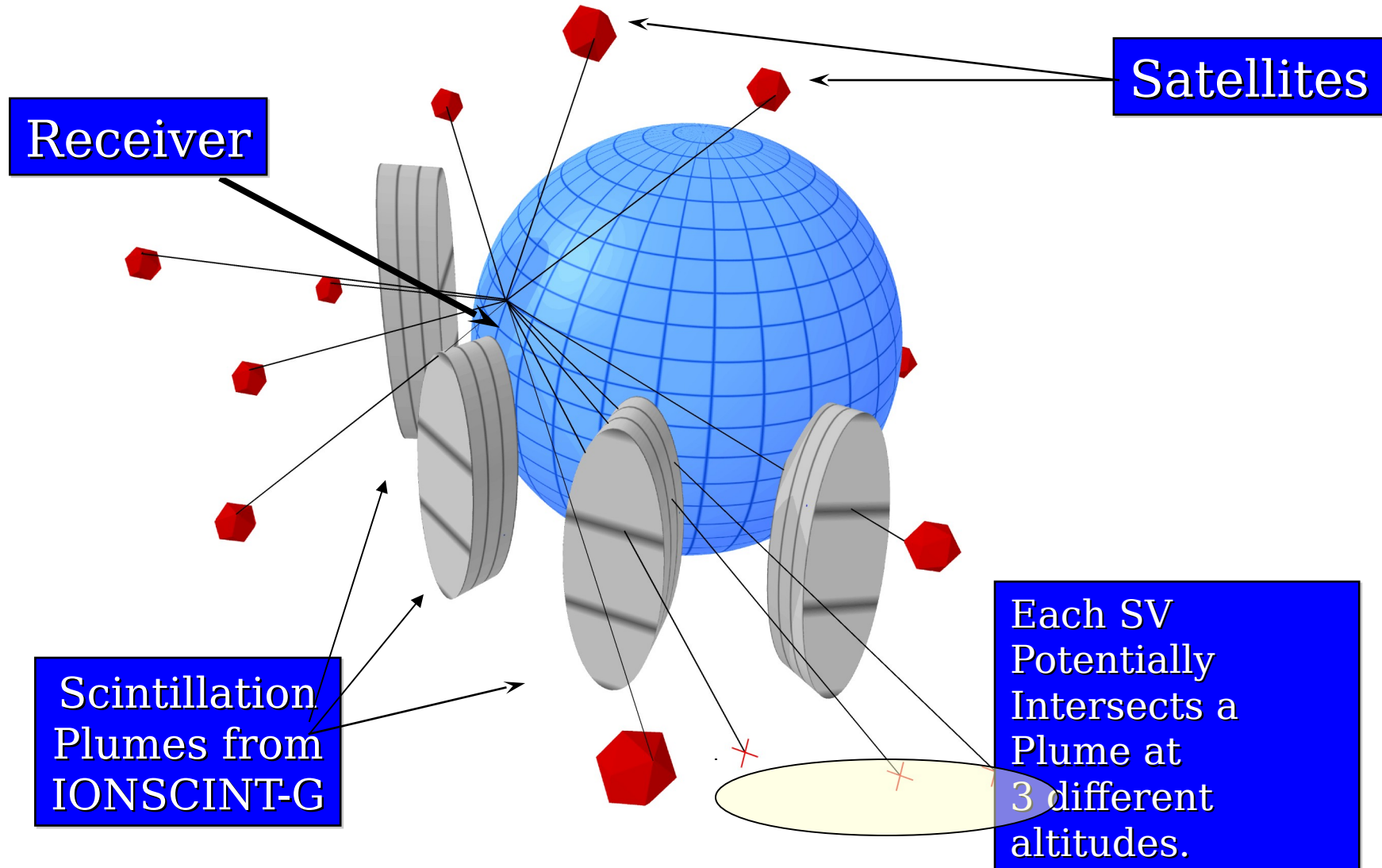
# DoD Space Weather (SWx) Modeling Methodology





# Scintillation Modeling Concept Cartoon

## Implementation in GIANT

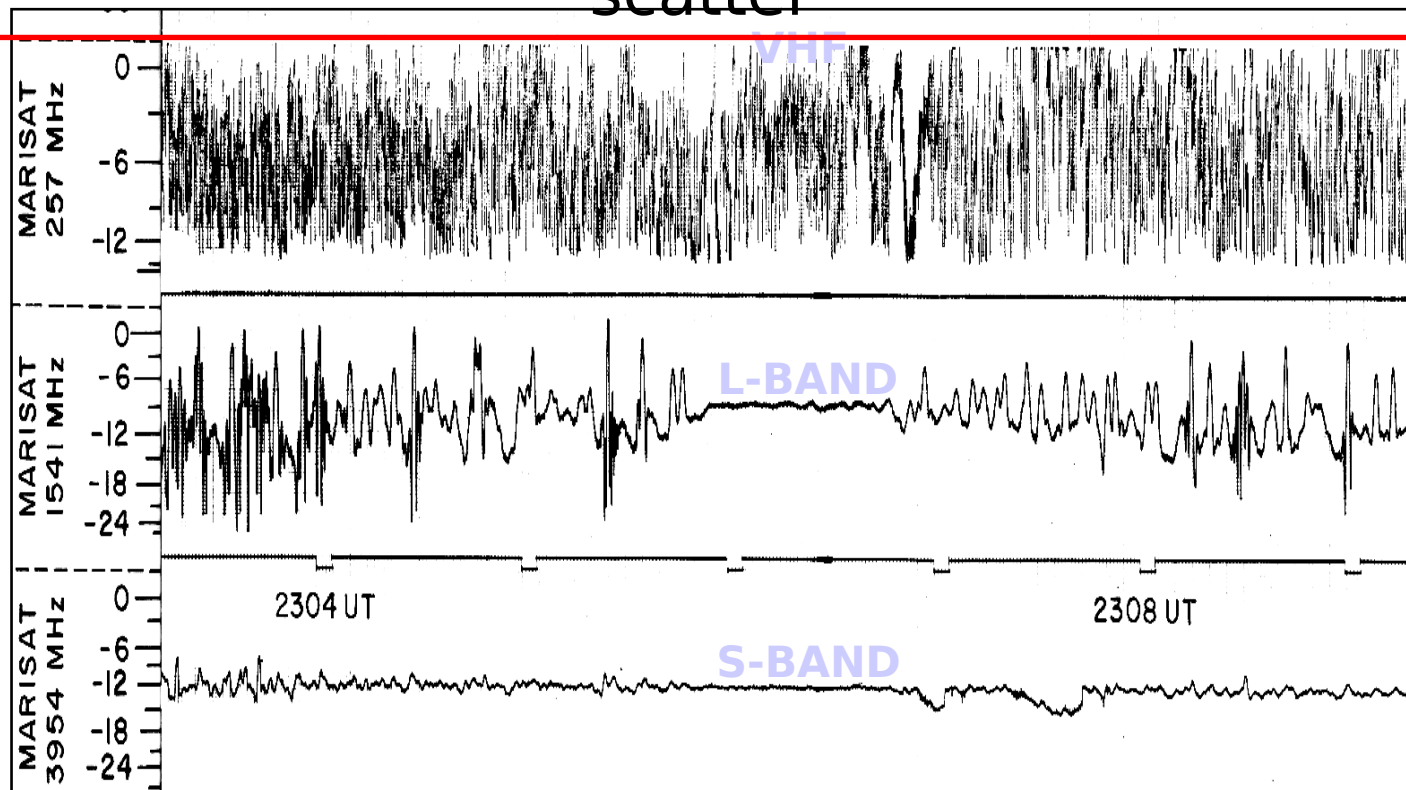




# Multi-Frequency Scintillation Observations on the Same Satellite Link

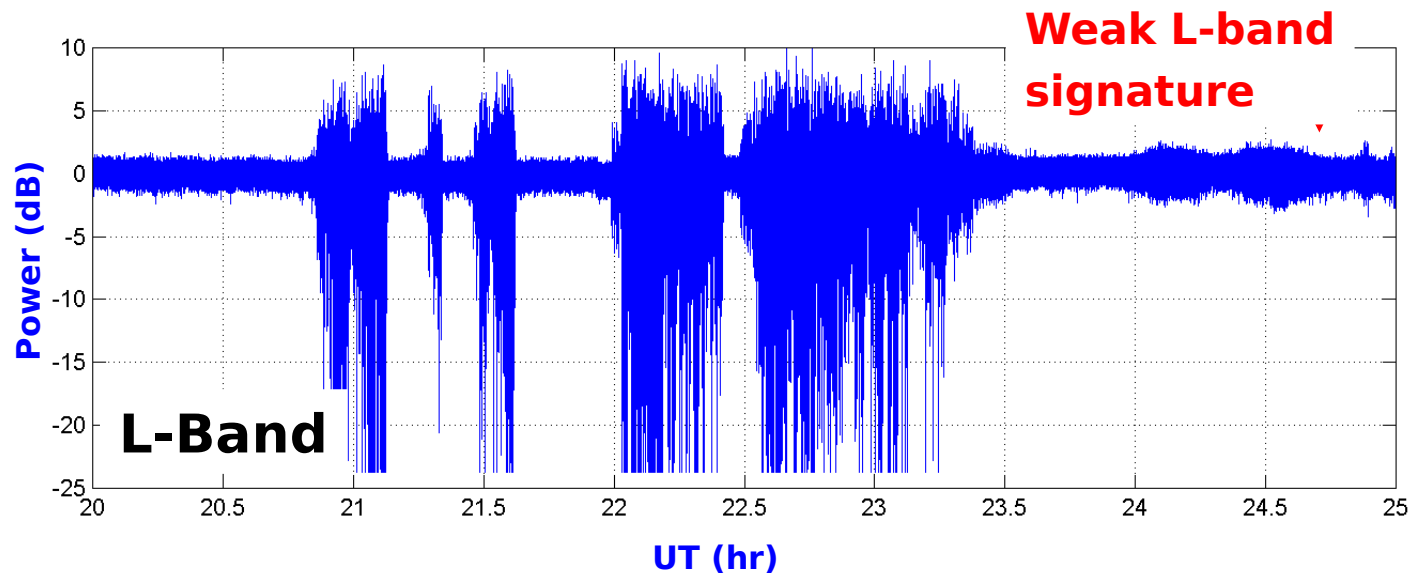
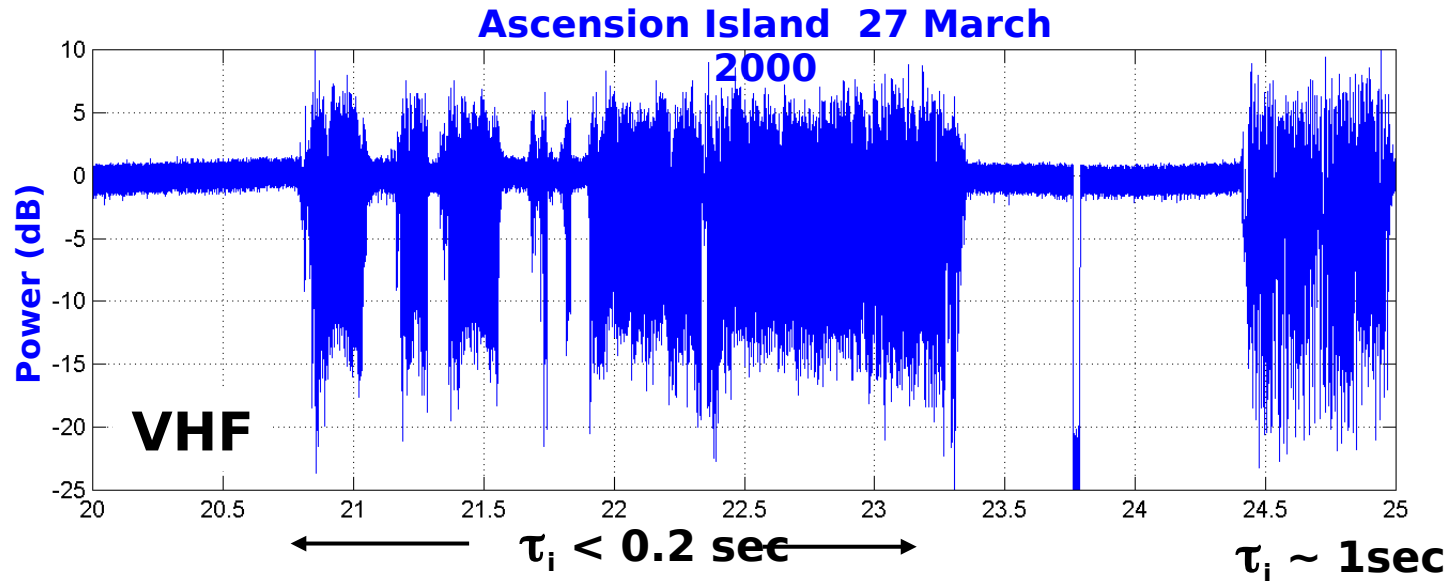


Scintillation strength decreases with increasing radio frequency, but precise scaling depends on 'strength of scatter'





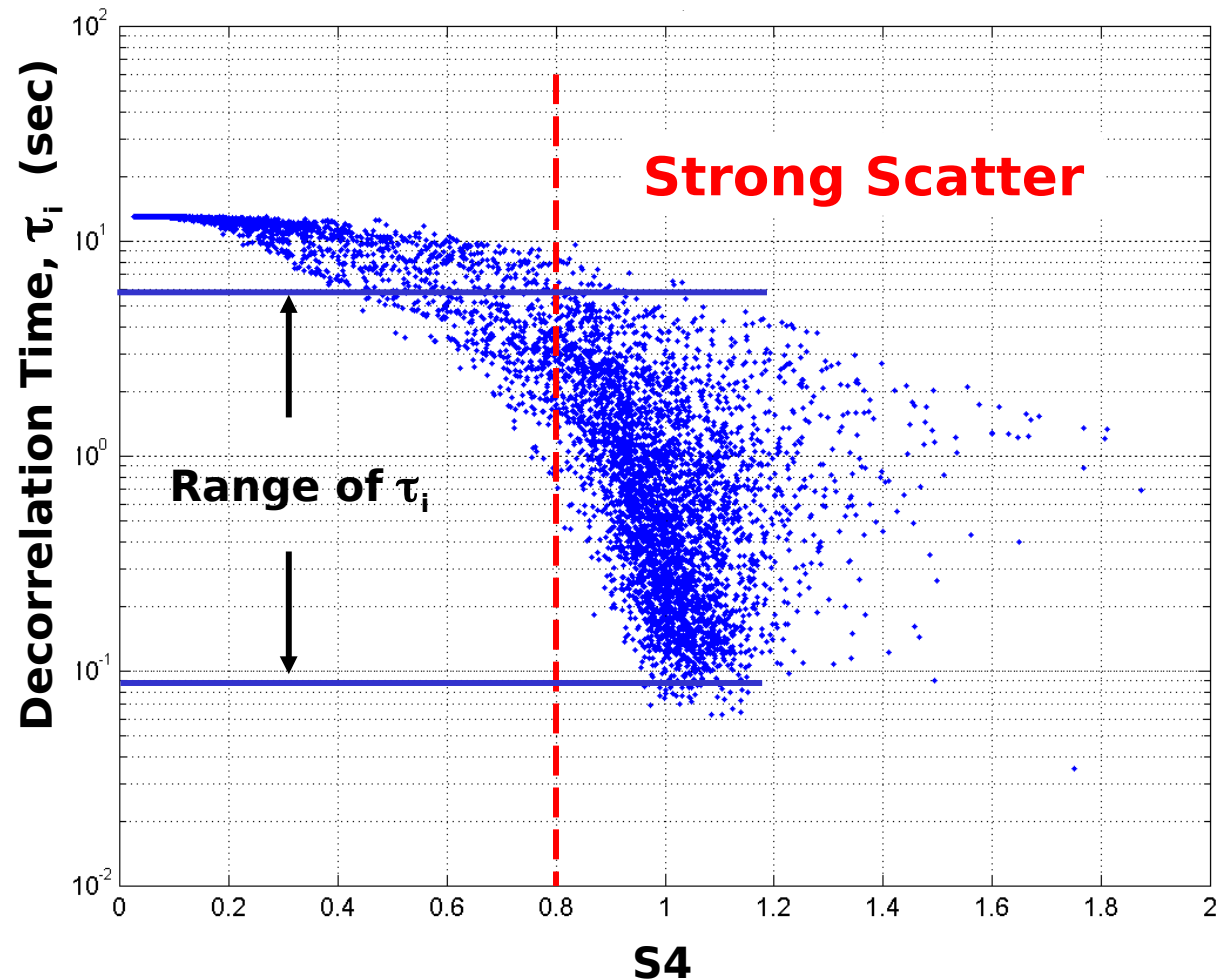
# Solar Maximum Conditions at Ascension Island: VHF and L-Band



# Proxy parameter to characterize strength of scatter: $\tau_i$

## Ascension Island Mar 2001

- Traditional scintillation index, S4, tracks gross magnitude of satellite signal fluctuations
- Signal decorrelation time,  $\tau_i$ , determined by lag at which autocorrelation function = 0.5, tracks temporal fluctuations
- A better indicator of strength of scatter (actual propagation conditions) than S4



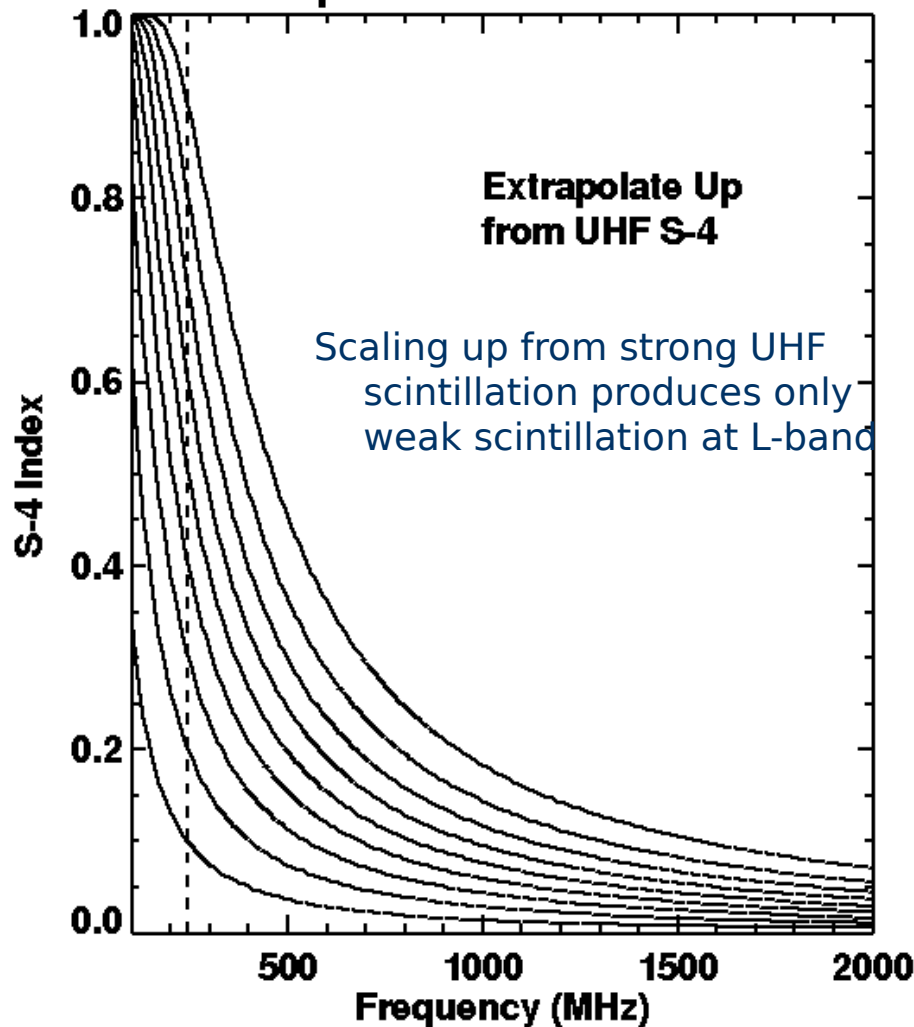


# Scaling from UHF to L-band by Phase Screen:

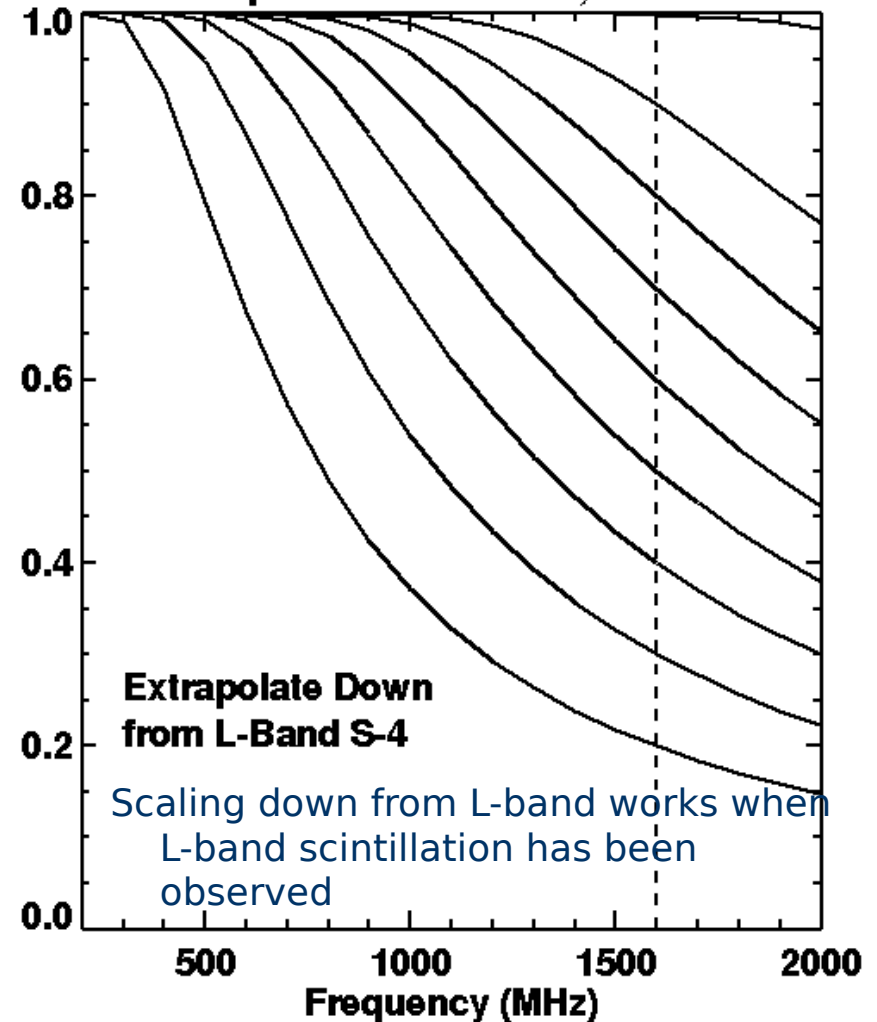


## The search for a consistent climatology

Extrapolation from 244 MHz

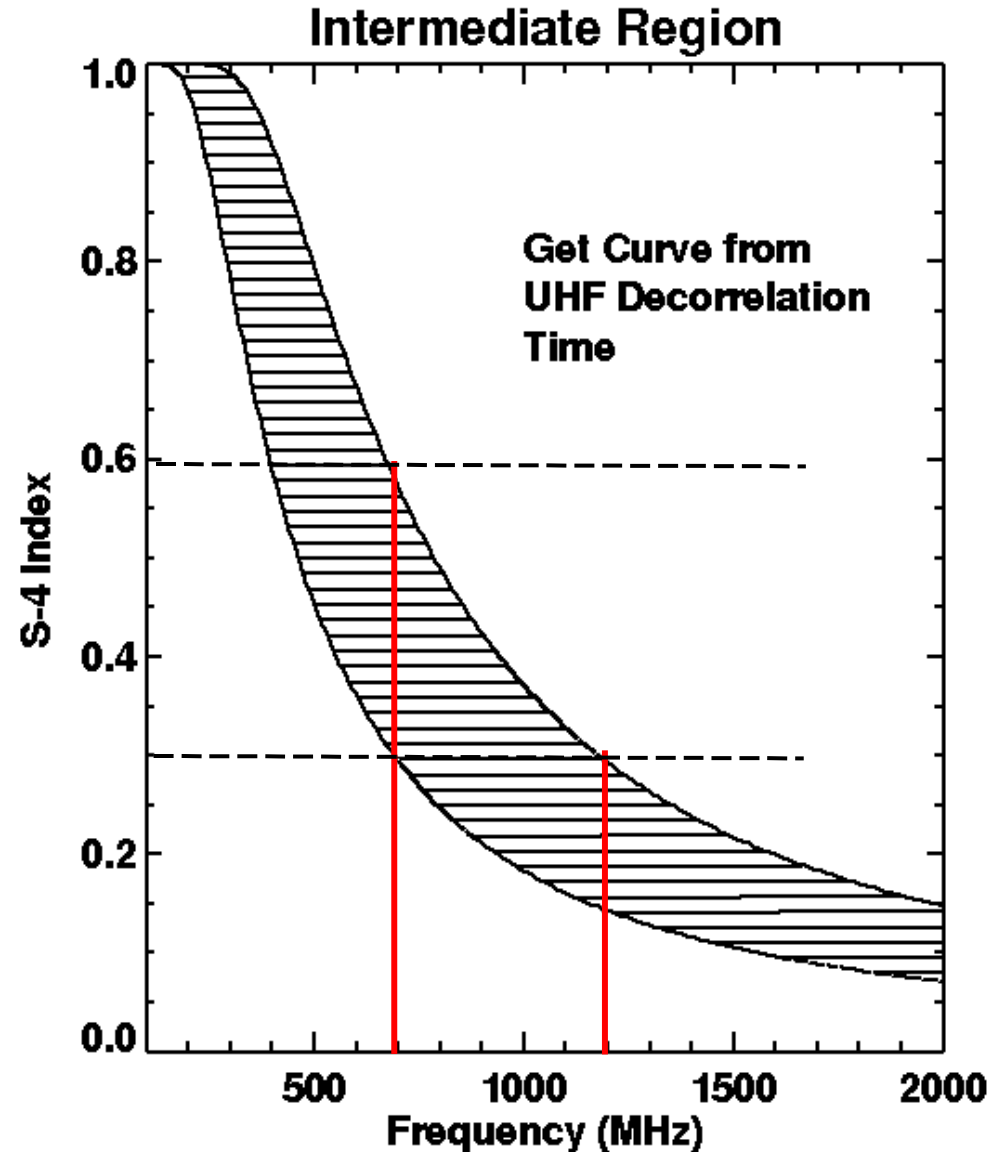
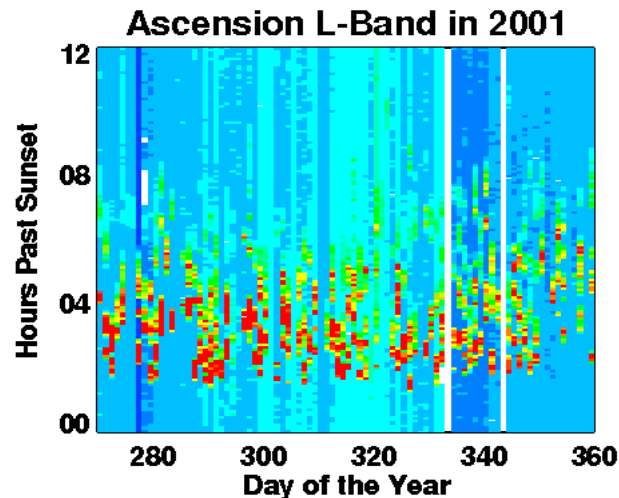
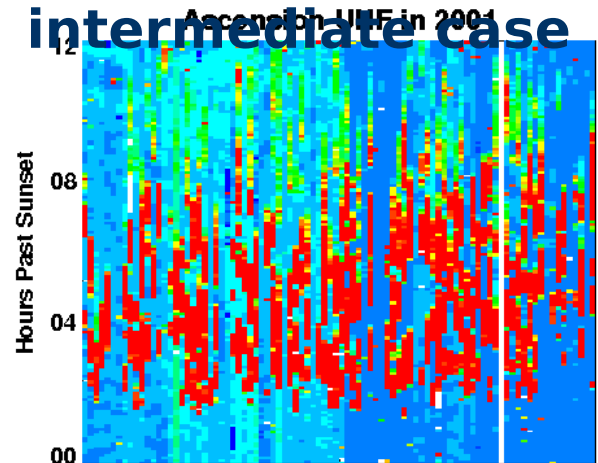


Extrapolation from 1,600 MHz



# High UHF and No L-band Activity

- **Technical solution:**  
**Exploit decorrelation**  
**time data for**  
**intermediate case**





# Summary

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- IONSCINT-G integration in GEOSpace Sep04
  - Simple model for navigation error to be incorporated by Dec04
  - Integration in GIANT supports complementary GPS nav error simulation analysis
- IONSCINT with DAFT on track for Dec04 delivery
  - Technical challenges addressed but multi-frequency data fusion/analysis effort largest remaining task
  - Leveraged with support from SMC for real-time broadband scintillation products
- Definition of code output for users remains TBD
  - Turbulence parameters provide complete information but require additional calculations to determine S4 for user-defined frequency and geometry
  - Goal to provide single definition of the scintillation environment for all users within a battlespace—need to create separate ‘environment’ and ‘effects’ models?